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ABSTRACT

This paper describes fourth-year outcomes (1993-94) of the Boeing Company-funded Applied Academics Project. Since the 1990-91 school year, the company has provided funds to improve and expand applied academics in 60 Washington high schools. Data were collected from pre- and post-surveys of students enrolled in the project's Applied Mathematics (AM) and Principles of Technology (PM) courses and their comparison groups (students enrolled in traditional mathematics and physics classes). A survey was also mailed to 49 sites that received Boeing funding. Findings indicate that AM students in every category scored significantly higher than their peers in traditional mathematics classes. PT students performed as well as their traditional counterparts when the variables for overall GPA and grades in mathematics and science were held constant. Low-achieving AM and PT students tended to demonstrate the greatest gain from the applied academic courses. They also gained confidence about their ability to learn mathematics and physics. Results of the site survey, to which 44 sites responded, suggest that Boeing funding was crucial in making the concept of applied academics a classroom reality. The number of participating students and schools increased dramatically, a trend that continued after funding ended. Five tables and 10 figures are included. Appendices contain a map of Boeing-funded sites in Washington State and copies of the surveys. (LMI)

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ED 381 892

THE Northwest Regional Educational Laboratory

EVALUATION REPORT

THE BOEING COMPANY APPLIED ACADEMICS PROJECT EVALUATION: YEAR FOUR

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March 1995

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The Boeing Company
Applied Academics Project
Evaluation: Year Four

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Mr. Rick Lengyel, Tech Prep administrator at The Boeing Company, who assisted in the evaluation design and in the review of the draft evaluation report.

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EXECUTIVE SUMMARY

Since the 1990-91 school year, The Boeing Company has taken the lead in forming partnerships with schools in the area of applied academics. Over the past four years, Boeing offered grants to some 60 high schools in Washington state to implement applied academics programs, and to over 60 educator interns, who spent six weeks during a summer discovering how their curriculum and instruction could be enhanced using workplace examples. Boeing's support for applied academics expanded to several community colleges in Washington and Oregon beginning in 1991. This effort made changes in post-secondary coursework to support Tech Prep offerings and to ensure that students would not have to enroll in remedial or basic academic courses at community colleges. The Boeing Company has invested approximately $3 million to improve and expand applied academics in Washington state. In addition, Boeing has implemented a summer student internship in manufacturing that runs for three consecutive summers with the same group of students, from the 11th grade through their first year in a community college. (The results of the internship are included in a separate report.)

Under contract with The Boeing Company, the Northwest Regional Educational Laboratory (NWREL) conducted the 1990-91, 1991-92, 1992-93, and 1993-94 evaluations of the Boeing-sponsored Applied Academics project. The fourth-year evaluation report of applied academics presents findings of pre- and post-assessments of applied academics students and their comparison group in Applied Mathematics (AM) and Principles of Technology (PT), and results of the survey of the impact of the Boeing Applied Academics project.

Major Findings

AM students were similar to comparison students in overall gradepoint averages (GPA) and grades in mathematics. This contradicts the misconception that AM serves only "low achievers." AM students had similar educational aspirations. The majority planned to have some post-secondary education after high school. In this study, a higher percentage (44 percent) of comparison students than AM students (33 percent) would like to be employed immediately after high school. Regarding student performance on AM tests, AM students gained significantly between the pre- and post-test. They also scored significantly higher than the comparison students in the post-test. AM students were more confident about their ability to learn mathematics after a year's AM course.

PT students and comparison students involved in this study appeared different in many ways. Compared with students in traditional physics classes, the PT students had lower gradepoint averages and lower grades in mathematics and science. Many more comparison-group students were university-bound (75 percent) than PT-group students (37 per-

cent). Comparison students also took more algebra courses. Regarding test performance, the comparison students scored significantly higher overall. However, PT students who took the same amount of algebra as the comparison group scored significantly higher on the PT items and not significantly different on the physics items. When overall grades in mathematics and science and GPA's were controlled, PT students generally scored higher on PT items (in some cases significantly so) than the comparison students. As for the physics items, PT comparison students whose overall grades in mathematics and science were "C" or higher or whose overall GPA was above 1.9 scored significantly higher than PT students with the same characteristics. No significant difference was found among students of the two groups whose overall grades in mathematics and science were below "C" or whose overall GPA was below 2.0.

The results of the survey of the impact of the Boeing Applied Academics project strongly suggest that Boeing funding was crucial in making the concept of applied academics a classroom reality. The funding was used for different purposes, particularly for purchasing equipment and material for applied academics. The number of students served and of schools offering applied academics courses increased dramatically during Boeing funding, a trend that remained even after funding stopped. Some schools have started to offer the second-year curriculum of PT and AM. Systematic data on the workplace performance of students who benefited from applied academics were not available. However, anecdotes from different sites indicated that those students were doing well in their jobs and were complimented by employers for their hands-on experience and comfort with equipment. Overall, all sites surveyed were very appreciative of the support they received from Boeing and hoped that Boeing would continue to support them. They made some suggestions for further business, industry, and labor support for educational partnerships.

Conclusion

The evaluation results of this year and of the previous three years strongly suggest that Principles of Technology and Applied Mathematics provide students challenging alternatives to traditional academic classes. This new approach appears to increase students' confidence in their ability to learn mathematics and science. The results of student tests in these two areas indicate that PT and AM were not only challenging for applied academics students, but also for those enrolled in traditional mathematics and physics classes (including those who are university-bound).

In the past two years when comparison groups were used, AM students in every category constantly scored significantly higher than their peers in traditional mathematics classes. Although PT comparison students appeared to score significantly higher at first glance, PT students were actually doing equally well and sometime better when certain variables were

kept constant, such as overall GPA and grades in mathematics and science. Since more "low achievers" were enrolled in the PT classes than in traditional physics classes, test scores tended to skew in favor of PT comparison students when student academic backgrounds were not controlled in analysis.

The results of student surveys show that AM and PT students who were at the lower end of academic achievement tended to gain greatest in applied academics courses. They were also found to be more confident about their ability to learn mathematics and science. However, AM and PT classes should not be confined to a particular group. They should be open to any student who wants a new perspective on mathematics and physics. It is important that these classes be viewed by students and staff as an alternative way, *but not an easy way*, to learn mathematics and physics. The appropriate amount of mathematics students take could determine how much they can benefit from AM or PT classes. Certain prerequisites need to be set for PT and AM classes so students enrolled in these classes can take full advantage of an alternative way of learning mathematics and science.

INTRODUCTION

This evaluation report is a study of the fourth year (1993-94) of the Boeing-funded high school Applied Academics project. The first section provides a background of the project, including a description of applied academics and the role of The Boeing Company. The next section reports evaluation findings from the surveys of students taking Applied Mathematics (AM) and Principles of Technology (PT), the pre- and post-test assessments of AM and PT students as compared to students enrolled in traditional mathematics and physics classes, and the survey of the impact of the Boeing Applied Academics project. The final section summarizes the major findings of the study and draws conclusions about the project, with references to results found in previous years.

Background

Educational reform in the 1980s was largely directed at halting a frightening decline in students' basic-skills performance. While the back-to-basics movement may have improved academic vigor, it did not engage many middle-level or at-risk students who saw more mathematics, more science, and more English requirements as more reasons to "turn off" or drop out. At the same time, most occupations today are becoming increasingly complex—requiring greater skills, for example, in solving problems, understanding systems, and working as a team member.

Applied academics is part of a larger effort to make high school curricula relevant to all students, a goal both of educators and of business and industry leaders. The aim is to make learning more meaningful by stressing applications of subject matter.

Applied academics gives more emphasis to the concrete (application and problem solving) than to the theoretical. It converts abstract concepts in geometry, algebra, and physics into practical and work-related examples. The same concepts found in academic disciplines are taught, but they are wrapped in real-life tasks. In addition, the approach addresses differences in learning styles among students and the need for students to acquire transferable knowledge and skills to succeed in the workplace.

Since the 1990-91 school year, The Boeing Company has taken a leadership role in forming partnerships with schools in the area of applied academics. Over the past four years, Boeing offered grants to some 60 high schools in Washington state to implement applied academics programs, and to over 60 educator interns, who spent six weeks during a summer discovering how their curriculum and instruction could be enhanced using workplace examples (see Appendix A for the location of these sites). Boeing's support for applied academics expanded to several community colleges in Washington and Oregon beginning in 1991. This effort made changes in postsecondary coursework to support Tech Prep

offerings and to ensure that students would not have to repeat high school applied academics courses at community colleges. The Boeing Company has invested approximately $3 million to improve and expand applied academics in Washington state. In addition, Boeing has implemented a summer student internship in manufacturing that runs for three consecutive summers with the same group of students, from the 11th grade through their first year in a community college.

Under contract with The Boeing Company, the Northwest Regional Educational Laboratory (NWREL) conducted the 1990-91, 1991-92, and 1992-93 evaluations of the Boeing-sponsored Applied Academics project. The resulting document, *Summary Report: Three-Year Report of The Boeing Company High School Applied Academics Project*, synthesizes the evaluation results of the project from 1990 to 1993. The report includes case studies, teacher surveys, student surveys, and student tests.

The evaluation design for the last two school years (1992-93 and 1993-94) incorporated significant modifications over prior years. While the formative evaluations for Years 1 and 2 centered on a description and assessment of the project environment, participants, project operations and outcomes, the evaluation for Years 3 and 4 took a more concentrated and comparative look at student outcomes. It includes a new test suitable both for both PT students and for regular physics students, and uses comparison groups for assessing student outcomes.

Applied Academics—The Why

Across the Northwest and the nation, teachers report that many of today's youth (those at risk, the "neglected majority," and the gifted alike) fail to see relevance in their curricula. Many subjects, including science, mathematics, history, economics, and language arts, are still taught in isolation with little or no reference to how these subjects are applied in the workplace and in other areas of life, or how they fit in with other school subjects. This is occurring at the same time that jobs are requiring higher proficiency in basic skills and technological understanding.

A four-year study (October 1993) conducted by the American Association for Advancement of Science points out that existing science curricula try to cover too much, do not teach enough practical application of science, and fail to integrate the subject with mathematics and technology. The study strongly recommends that students be taught how science impacts their lives rather than memorize many irrelevant and useless details.

In a regional study of entry-level workers in the Northwest and Pacific (Owens, Lindner, and Cohen, 1989), employers reported a growing gap between the basic skills needed by employers and those available in the applicant pool for entry-level positions. Mentioned

most often are serious deficiencies in reading, writing, mathematics, communications, and problem-solving skills.

Recent National Assessment of Education Progress (NAEP) test results reveal that many children and youth lack adequate basic skills used in thousands of jobs today. In areas such as science and mathematics, the performance of U.S. students continues to be lower than that of students in almost all other industrial countries. This may be due in part to U.S. students not taking sufficient science and mathematics courses. It may also result from the way in which most science and mathematics courses are taught. For millions of U.S. youth, a hands-on, applied approach is far more effective than a "theoretical" approach.

An analysis of national data on high school students by the Educational Testing Service (ETS) (Applebee, Langer, and Mullis, 1989) indicates that:

> Sixty-one percent of the 17-year-old students could not read or understand relatively complicated material, such as that typically presented at the high school level. Nearly one-half appeared to have limited mathematics skills and abilities that go little beyond adding, subtracting, and multiplying with whole numbers. More than one-half could not evaluate the procedures or results of a scientific study, and few included enough information in their written pieces to communicate their ideas effectively (p. 26).

The ETS study concludes that:

> For qualitatively different gains to occur, the goals of instruction need to be reconsidered. Teaching decisions were once guided by a hierarchy suggesting that students must first learn facts and skills and later learn to apply them. Yet many educators now recognize the limitations of this stepping-stone view of education. Educational theory and research suggest a different pattern of generative teaching and learning, where learning content and procedures and how to use this learning for specific purposes occur interactively. . . . When students engage in activities that require them to use new learning, both their knowledge of content and skills and their ability to use them develop productively together (p. 40).

Most reports on educational reform written over the past 10 years focus on strengthening the curriculum of college-bound students with an increased emphasis on academic learning. However, 50 percent of students do not enter college, and job requirements are continually rising. They, too, need a strong understanding of the basics (Grant Foundation, 1988).

The National Assessment of Vocational Education (NAVE) (Wirt et al., 1989) empirically tested the idea that high school vocational education contributes to the development of students' academic skills and that some students learn academic skills more readily in an applied context. Using data from a nationally representative sample of students from the high school class of 1982, they found that (1) mathematics-related vocational courses, as structured in the early 1980s, provided fairly low levels of applications of mathematics; (2) mathematics-related vocational courses accounted for approximately 18 percent of all vocational courses for all students; and (3) for college-bound students, participation in a specific vocational mathematics course (such as business mathematics) increased their mathematics proficiency equivalent to participation in an algebra course (pp. 79-81). The NAVE study concluded than "an objective of federal policy in vocational education should be to encourage the expansion of academic learning in vocational education and the integration of academic and vocational curricula" (p. 83).

In his testimony before the Senate Subcommittee on Education, Arts, and Humanities, Charles Benson, director of the National Center for Research in Vocational Education (1989), stated that "The case for integration [of academic and vocational preparation] stands on three main—and somewhat interrelated—arguments: economic necessity; findings from the field of cognitive science; and social justice with respect to the distribution of academic and vocational learning." The concept of integrating academic and vocational education is a major premise of the new Carl Perkins Vocational and Applied Technology Education Act.

In their report at the second annual staff development conference, sponsored by the State Vocational Education Consortium of the Southern Regional Educational Board (SREB), Bottoms and Korcheck (1990) laid out a meaningful statement on the need for integrating academic and vocational education.

> The thinking and problem solving skills of high school students will develop more readily if they understand the connection between what they are learning and how it can be used. One way students can achieve this insight is if meaningful applied learning activities are integrated into communications, mathematics, and science courses and if essential concepts and skills from these courses are coordinated with instruction in vocational courses. Once students understand the application of academic knowledge, they are far more likely to recall and apply information than if they rely on rote memorization (p. 16).

Well-documented student impact data supporting the gains made by students in applied academics classes are not yet available. However, third-year findings of some schools participating in applied academics programs through SREB show that students are getting

higher grades in the needed subject areas covered than they received in prior years. The findings also show that these students are more likely, after having had a course like Applied Mathematics, to take more advanced mathematics and science classes.

Business and industry spend billions of dollars each year to teach employees skills that many employers feel should have been taught while they were still in high school. The United States is facing losses in global economic competition that will have significant economic and social consequences in the years ahead unless its workforce is brought up to world-class standards. The applied academics movement is one strategy for improving the quality of the U.S. workforce by strengthening the school-to-work transition.

Applied Academics—The What

"Applied academics" is a generic term used to describe curricula developed over the past decade that show the relevance of subjects such as physics, mathematics, and language arts in the workplace. These curricula are aimed particularly at the two middle quartiles of students who may find general and college-bound classes irrelevant. Applied academics curriculum packages have been developed through multi-state consortium efforts by two companies: the Center for Occupational and Research Development (CORD) and the Agency for Instructional Technology (AIT). They usually include hands-on laboratory activities for students as well as high-interest videos to draw students' attention to the real-world applications of the concepts taught. Below are descriptions of three applied academics programs supported by Boeing. A fourth consortium-developed package is Application in Biology/Chemistry, which was not completed in time to be included in the Boeing Applied Academics project.

Applied Communications. AIT developed the Applied Communications course to teach students communications skills needed for success in the workplace. Developed in conjunction with state departments of education and provincial ministries of education and with educators in 42 states in the U.S. and several provinces in Canada, the learning materials are divided into 15 instructional modules totaling 150 lessons. They can be used to broaden existing courses or as the basis for a year-long course. Each module includes 10 lessons of 40 to 44 minutes each incorporating a variety of learning activities and experiences.

Lessons 1 through 7 of each module provide instruction and practice in communications skills as they are generally used in the workplace. Lessons 8 through 10 feature activities designed to develop and refine communications skills in five major occupational areas: agriculture, business/marketing, health occupations, home economics, and technical/trade/industrial. Each module features two video programs. The student work-text supplies individual task sheets with lists of goals and objectives, background information, observation checklists, self-evaluation forms, worksheets, schedules, letters, and charts.

Applied Mathematics. With financial assistance from 42 state vocational-education agencies and guidance from mathematics and vocational educators, CORD developed 33 units of Applied Mathematics. The materials are designed to meet the needs of students in the two middle quartiles of the high school population. The 25 units consistently use hands-on activities and work-based applications to transform abstract concepts into concrete experiences. In the 1993-94 school year, approximately 508,000 students were enrolled in Applied Mathematics classes in 50 states.

The overall course includes materials that focus on arithmetic operations, problem-solving techniques, estimation of answers, measurement skills, geometry, data handling, simple statistics, and the use of algebraic formulas to solve problems. These first-year-level materials are designed for use in a one- or two-year course for academic credit toward high school graduation. Alternatively, they may be used in part or infused as needed into existing vocational courses. Written generally at an eighth-grade reading level, the materials are deemed appropriate for high school students in grades 9 through 12 who are not necessarily baccalaureate-bound. Second-year-level materials are now available and being used by some high schools and community colleges across the nation.

Principles of Technology. In 1993-94, Principles of Technology was taught in 50 states with approximately 278,000 students. In their 1988 review of materials, the American Association for the Advancement of Science cited PT materials as the best technical physics curriculum available. Developed by a consortium of 47 states and two Canadian provinces, PT is a high school course in applied science aimed particularly at vocational-technical students to help them better understand modern technology. Students taking PT may go on to college to complete degrees in areas such as industrial engineering; others complete associate degrees at a community college or go directly to work.

The curriculum covers 14 units of study in a two-year period—though many schools choose to offer only the first seven units in a one-year course. The 14 units of study include the following: force, work, rate, resistance, energy, power, force transformation, momentum, waves and vibrations, energy converters, transducers, radiation, optical systems, and time constraints.

Principles of Technology is being taught nationally by science teachers, by vocational teachers, and by teams of both in some schools. Some special training is required, and time is needed to make sure a laboratory exercise is set up correctly for each unit. High schools may choose to offer students elective credit in science, vocational education, and/or mathematics depending on local and state policies. In Washington, staff training is provided each summer by the Office of Superintendent of Public Instruction.

Summary. According to CORD, materials in each of the above applied-academics curriculum packages have the following features:

- Use modularized student units
- Incorporate teacher-empowering guides for each unit
- Include competency-based objectives
- Are enhanced by an instructional video for each unit
- Are written at an estimated eighth-grade reading level
- Target secondary vocational students as the primary audience, are also useful in postsecondary adult learning sites
- Emphasize holistic learning
- Can be infused into vocational courses or taught alone as a credit course by either vocational or academic instructors—or a team that includes both
- Are not meant to replace "traditional" academic courses for the top 25 percent of the student population
- Emphasize developing teamwork skills in students

In addition, the effectiveness of the materials was validated through field testing.

Role of The Boeing Company

Convinced that new applied academics models would help ensure a more qualified workforce, The Boeing Company—the nation's largest aerospace corporation—convened a company taskforce that met with Washington education leaders to determine what help might be needed to ensure that more than a handful of schools would make the new coursework available. The taskforce of operation managers and corporate leaders prepared an options paper for top management. President Frank Shrontz and Senior Vice President for Operations Deane Cruze agreed that a significant investment of company profits would have a long-term payoff not only for Boeing but also for Washington state, no matter where graduates of these programs might eventually be employed. Educators agreed that Boeing could help by:

1. Using its influence as the state's major employer to convince education policymakers at local and state levels of the benefits of applied academics courses

2. Validating that new kinds of basic skills are needed in the workplace

3. Providing seed money to local schools with applied academics programs to purchase equipment and materials and to reimburse expenses for teacher release time

4. Providing opportunities for applied academics teachers to see their subject areas being used in state-of-the-art work settings

5. Providing incentives and resources to encourage high school and community college faculty to link their programs and to encourage community college faculty to change selected curricula to applied approaches

EVALUATION FINDINGS

This part of the report presents the fourth-year (1993-94) evaluation results of AM and PT student surveys, student tests, and the survey of the impact of the Boeing Applied Academics project (1990-1994).

Student surveys attached to students tests were administered to AM students, PT students, and their comparison students at the beginning and end of the 1993-94 school year. Each site followed the guidelines shown below that were provided by NWREL in selecting comparison students:

- Students in comparison groups should meet the prerequisites required for admission to the AM or PT class.
- Students in comparison groups should be at approximately the same grade level as those enrolled in the AM or PT class.
- Students in comparison groups should be taking a mathematics class that is comparable in content to the AM or PT class.

Applied Mathematics Student Survey and Test

Students were asked to complete a short survey before they started their test. The survey items could then be used as variables to be controlled in analyzing student test results.

In the 1993-94 school year, 1,340 students took the pre-AM test; 309 AM students and 75 AM comparison students took both the pre- and post-AM tests.

The pre- and post-tests of AM were developed by NWREL in 1991 for the Boeing project; this is the fourth year they have been used. Teacher feedback from the previous three years suggests they are good measures of student learning in AM classes. This set of tests covered units one through 11 of the AM curriculum. These units were selected rather than the entire 15 units since many teachers indicated that they usually covered no more than 11 units in one year. Each test has 38 items.

Student Demographics

The majority of AM students (64 percent) were male while 51 percent of the comparison students were male. All comparison students were in grades 9 and 10. There was much wider grade-level distribution among the AM students: 18 percent were in grade 9; 50 percent in grade 10; 22 percent in grade 11; and 10 percent in grade 12. Figure 1 summarizes the grade-level distribution of AM students and the comparison students.

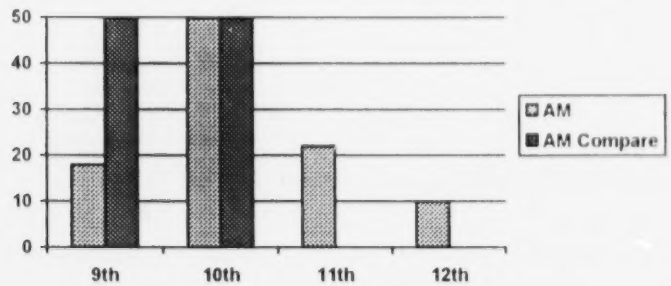


Figure 1. Grade-Level Distribution of AM Students and AM Comparison Students

A higher percentage of white students (73 percent) was in the AM student group than in the comparison group (60 percent). However, more Hispanic students (34 percent) were in the comparison group than in the AM group (16 percent). Both groups had a relatively low percentage of Black students (2 percent for the AM group; 1 percent for the AM comparison group). Figure 2 summarizes racial backgrounds of the two groups.

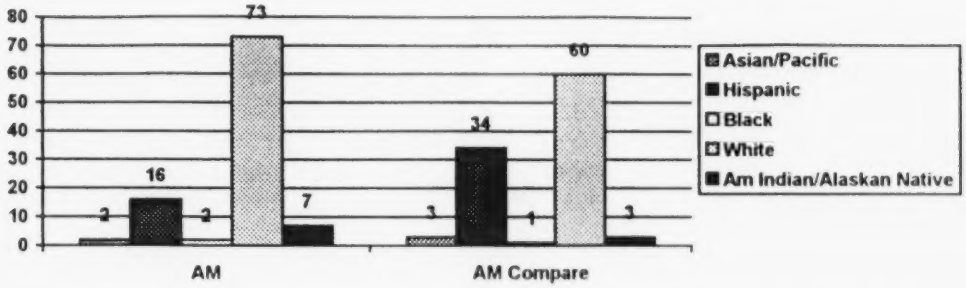


Figure 2 Racial Backgrounds of AM Students and AM Comparison Students

Student Overall GPA and Mathematics Background

As shown in Figure 3, the student-reported overall gradepoint averages in the previous year were distributed along a bell-shaped curve. With few students reporting an overall GPA of over 3.5 or under 1.0 at both ends of the bell, the majority of students reported an overall GPA between 1.0 and 3.5. Almost half of the students from both groups reported their overall GPA between 2.0 and 2.9.

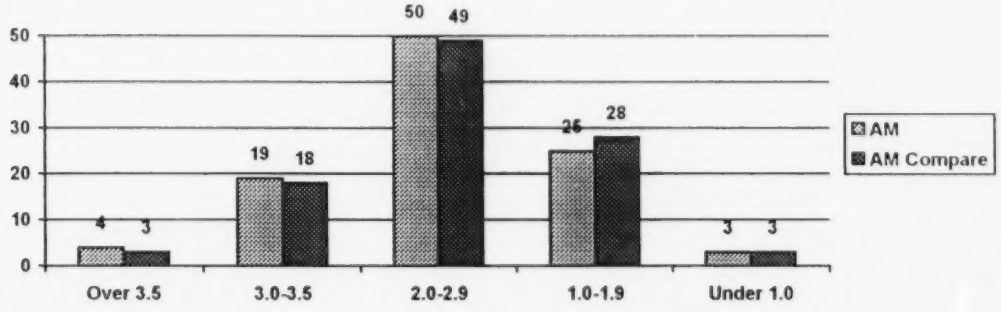


Figure 3. AM Students' and AM Comparison Students' Overall GPA in the Previous Year

When asked their overall grade in mathematics, the majority of students reported B's and C's, with a small percentage reporting A's and D's. Figure 4, which summarizes the overall grade in mathematics, is similar to Figure 3 in patterns of distribution.

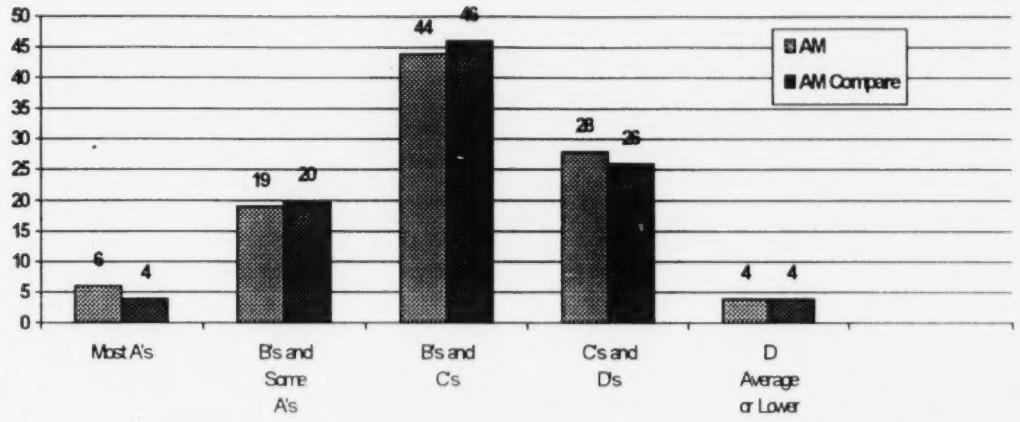


Figure 4. AM Students' and AM Comparison Students' Overall Grades in Mathematics

Figure 5 summarizes student self-ratings of their ability to learn mathematics in the pre- and post-survey. In the pre-survey, AM students and AM comparison students were similar in their self-rating. In the post-survey, however, AM students rated themselves higher than the comparison students and also higher than they rated themselves in the pre-survey. In the post-survey, 65 percent of AM students and 47 percent of AM comparison students rated their ability to learn mathematics as "excellent" or "good," about a nine percent increase for the former group and a 12 percent decrease for the latter group compared with their self-rating in the pre-survey.

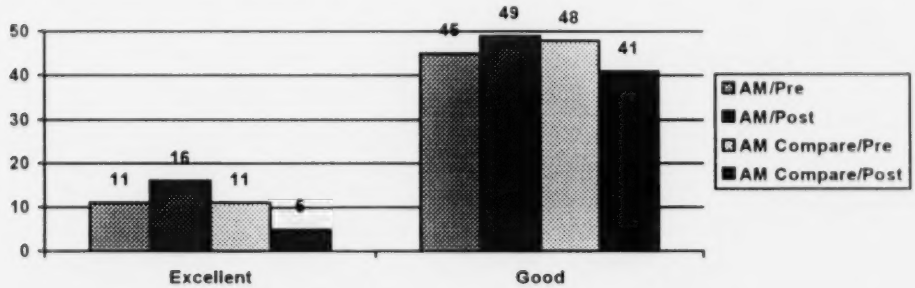


Figure 5. AM Students' and AM Comparison Students' Self-Rating of Their Ability to Learn Mathematics in Pre-Survey and Post-Survey

Student Post-Secondary Plans

Table 1 summarizes what AM students and AM comparison students planned to do immediately after high school. Since students may plan to do more than one thing, they were asked to circle all the choices that apply to them. Table 1 shows that the majority of the students will continue with some kind of postsecondary education after high school. A third of the AM students planned to get a job after high school, whereas almost half of the comparison students wanted to do the same. There were more variations of responses between the pre- and post-survey for the comparison students. For example, in the pre-survey, 23 percent indicated that they planned to enroll in a four-year college or university, but in the post-survey, only 12 percent indicated that they would like to do so. This may be due to the fact that all students were from grades 9 and 10 and were more uncertain than the AM students, some of whom were already in grades 11 and 12. It is interesting to note that on the post-survey a larger percentage of AM than of comparison students was interested in attending both community and four-year colleges.

Table 1

AM Students' and AM Comparison Students' Postsecondary Plans

Postsecondary Plan	Percent of Respondents			
	AM (N = 309)		AM Compare (N = 75)	
	Pre	Post	Pre	Post
Enroll in a community college	39	35	28	29
Enroll in a four-year college or university	19	18	23	12
Enroll in a trade or technical school	14	19	12	17
Join the military	12	10	9	8
Get a job	32	33	52	44
Something else	11	11	7	9

Pre- and Post-Tests of AM

Results of One-Way Analysis of Variance (ANOVA) show that AM students scored significantly ($P<.05$)* higher in the post-test (18.9) than they did in the pre-test (15.7). Their scores on the post-test increased by 20 percent compared with their scores on the pre-test. No significant gains were found among the AM comparison students between the pre-test (13.0) and the post-test (14.7).

* Statistical significance in this report is determined at the .05 level.

AM students scored significantly higher than comparison students in both pre- and post-tests. By controlling gender, grade level, overall grade in mathematics, and overall GPA, AM students still scored significantly higher than the comparison students.

Principles of Technology Student Survey and Test

A total of 2,104 students took the PT student pre-survey, and 773 took both pre- and post-PT surveys and tests. Among them, 489 were PT students and 284 PT comparison students. This section presents survey and test results of 773 students who took both pre- and post-PT surveys and tests.

The 41-item pre- or post-test of PT used for 1994 consists of 20 items selected from the pre- and post-tests of PT developed by NWREL in 1991, and 21 items from an introductory physics test designed for the American Association of Physics Teachers.

Student Demographics

Seventy-one percent of PT students and 64 percent of the comparison students were male. Fifty percent of the comparison students were in grade 12, while the same percentage of PT students were in grades 10 and 11. Figure 6 shows the grade-level distribution of PT and comparison students.

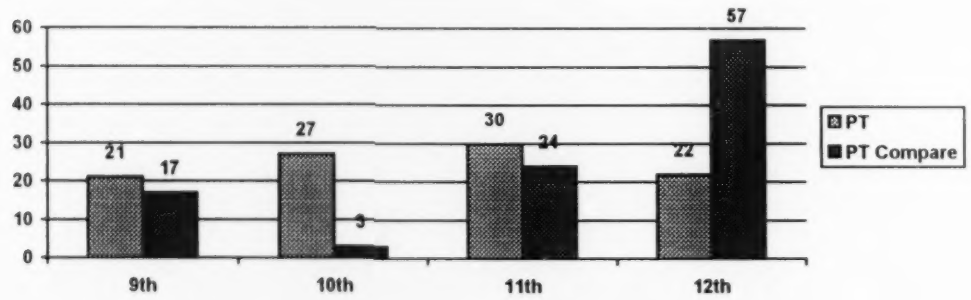


Figure 6. Grade Levels of PT Students and PT Comparison Students

As shown in Figure 7, the majority of PT students (80 percent) and comparison students (86 percent) were white. There were more Hispanic students (8 percent) in the PT group

than in the comparison group (2 percent). There were more Asian or Pacific Islander students in the comparison group than in the PT group.

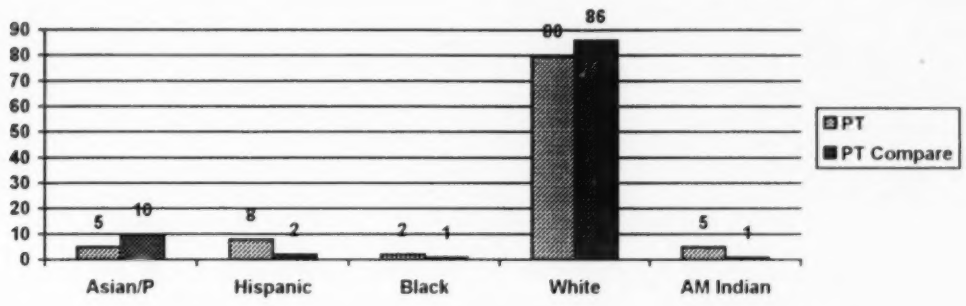


Figure 7. Racial Backgrounds of PT Students and PT Comparison Students

Student Overall GPA and Math Background

Compared with PT students, PT comparison students had higher overall GPA's and grades in mathematics and science. More PT students reported overall grades in mathematics and science between "C" and "D" and overall GPA's between 1.0 and 1.9 than did students in the comparison group. Figures 8 to 10 summarize PT and comparison students' overall grades in mathematics and science and overall GPA.

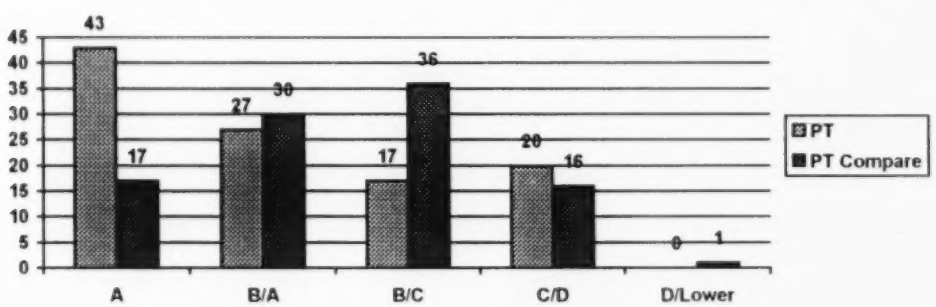


Figure 8. PT Students' and PT Comparison Students' Overall Grades in Mathematics

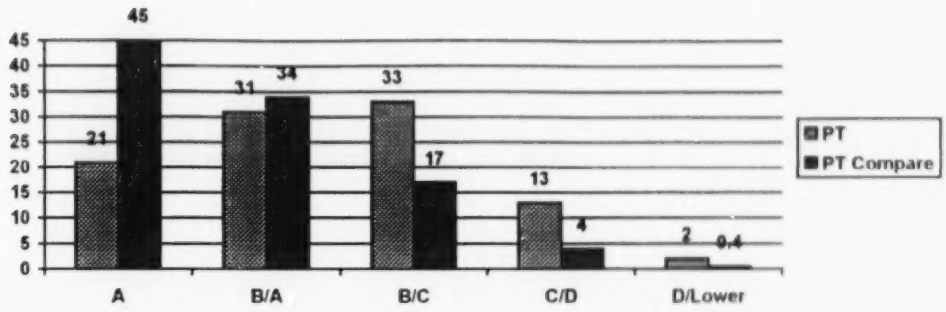


Figure 9. PT Students' and PT Comparison Students' Overall Grades in Science

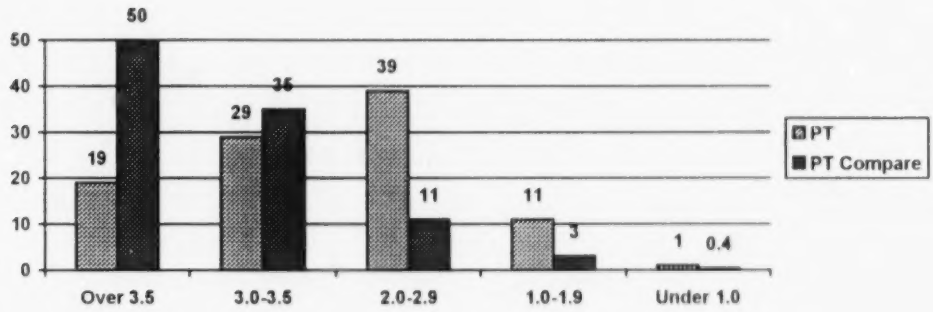


Figure 10. PT Students' and PT Comparison Students' Overall GPA

Table 2 shows that the comparison students took more upper-level mathematics courses than did PT students. For example, 73 and 74 percent of the comparison students took geometry and Algebra II, respectively, whereas 37 and 43 percent of the PT students did so. Forty-seven percent of the comparison students took Algebra III, as compared to 7 percent of PT students.

PT and Comparison Students' Postsecondary Plans

The results of the pre- and post-surveys show that the majority of students from both groups indicated that they planned to enroll in a community college or a four-year college immediately after high school. More students in the comparison group (75 percent) planned to go to a four-year university, while more students in the PT group planned to enroll

in a community college. The results of pre- and post-surveys also show that more PT students indicated that they planned to enroll in a community college, and fewer students indicated that they planned to enroll in a four-year university. However, the results of pre- and post-surveys show a reversed pattern for the comparison students. See Table 3 for a *summary*.

Table 2

Mathematics Courses Taken by PT Students and PT Comparison Students

Mathematics Course	Percent of Students Enrolled	
	PT	Comparison
General, Business, or Consumer Mathematics	24	23
Pre-algebra	50	44
Algebra I	71	66
Geometry	43	74
Algebra II	37	73
Trigonometry	12	57
Pre-calculus or Algebra III	6	47
Calculus	3	22
Technical Mathematics	1	0.7
Other mathematics courses	8	6

Table 3

PT Students' and PT Comparison Students' Postsecondary Plans

Postsecondary Plans	Percent of Students			
	PT		Comparison	
	Pre	**Post**	Pre	**Post**
Enroll in a community college	29	**35**	17	**21**
Enroll in a four-year college or university	44	**37**	81	**75**
Enroll in a trade or technical school	18	**16**	4	**4**
Join the military	8	**8**	5	**4**
Get a job	27	**26**	19	**19**
Something else	11	**9**	6	**4**

Pre- and Post-Tests of PT

PT students scored significantly higher in the post-test (18.1) than they did in the pre-test (15.1). The comparison students scored significantly higher than PT students in both the pre-test (18.2 vs. 15.1) and post-test (19.9 vs. 18.1). Female students in both groups scored significantly lower than male students in the post-test.

On the PT items selected from the Principles of Technology test in the post-test, PT students at grade 9 scored significantly higher than did PT comparison students of the same grade level. No difference was found at grade 10. At grades 11 and 12, the comparison students scored significantly higher than PT students. This could be attributed to the fact that PT comparison students from grades 11 and 12 took more advanced algebra courses than PT students (see Table 2). A pattern was found for both PT students and the comparison students: the higher the level of algebra students took, the higher they scored on the PT items as well as on the physics items. However, when the level of algebra is constant, PT students scored significantly higher than did the comparison students on the PT items in the post-test. The results of Factorial ANOVA indicated that the level of algebra used as a covariate had a significant impact on both PT and comparison students' scores on the post-PT test. When overall grades in mathematics and science and the overall GPA were controlled, PT students generally score higher (in some cases significantly higher) than did the comparison students on PT items in the post-test.

On physics items selected from the introductory physics test in the post-test, no significant difference was found at grades 9 and 10. PT comparison students from grades 11 and 12 scored significantly higher. Again this is because the comparison students at grades 11 and 12 took higher levels of algebra than did PT students of the same grade level. Keeping the level of algebra constant, no significant difference was found between PT and comparison students for their scores on the physics items in the post-test. Comparison students whose overall grades in mathematics and science were above "C" or whose overall GPA was above 1.9 scored significantly higher than PT students with the same characteristics. However, no significant difference was found among students of the two groups whose overall grades in mathematics and science were below "C" or whose overall GPA was below 2.0.

Survey of the Impact of the Boeing Applied Academics Project

To assess the impact of the Boeing Applied Academics project, a survey was sent to 49 sites that received Boeing funding between 1990-91 and 1993-94. Forty-four sites returned the completed survey.

A total of 54 schools from these 44 sites directly received Boeing funding for applied academics. Six of these schools also received services relating to applied academics from community colleges or consortia funded by Boeing for applied academics.

Use of Boeing Funding

Boeing funds were used for different purposes. In descending order, the following are the percentages of sites reporting how they used the Boeing funds:

- Purchase equipment for applied academics (95.5%)
- Purchase applied academics materials (77.3%)
- Train staff (52.3%)
- Develop or modify curriculum for applied academics (38.6%)
- Plan articulation (13.6%)

Number of Students Served

In the survey each site was asked to estimate the number of students in its school district enrolled in applied academics courses (Principles of Technology, Applied Mathematics, and Applied/Business Communication) the year before receiving Boeing funding, during funding, and after funding ended. As shown in Table 4, the number enrolled in applied academics courses during funding was over three times greater than it was before funding. The number continued to increase after funding stopped. Although more students were enrolled in the PT course after funding ended, the number enrolled in AM and AC courses grew much faster than it did for the PT course. After funding ended, enrollment in Applied Communication was 14 times greater than it was prior to funding; in Applied Mathematics, five times; and in Principles of Technology, approximately three times greater. These results may reflect the relative cost these three curricula, where PT is by far the most expensive.

Table 4

Student Enrollment in Applied Academics Courses before, during, and after Boeing Funding

	Number of Students Enrolled		
Course	Before	During	After
Principles of Technology	836	1910	2446
Applied Mathematics	309	1127	1519
*Applied Communication or Business Communication	107	1367	1540
Total	1252	4404	5505

*Some high schools use Applied Communication to revitalize traditional business English and communication courses.

Number of Schools Offering Applied Academics Courses

As shown in Table 5, the number of schools offering applied academics courses also increased after Boeing funding. Prior to funding, 56 schools offered applied academics courses. After funding ended, the number increased to 175, an increase of over 200 percent. This is clear evidence of the multiple effect The Boeing Company has had on the expansion of applied academics in Washington.

Table 5

Number of Schools Offering Applied Academics Courses before and after Boeing Funding

	Number of Schools	
Course	Before	After
Principles of Technology	30	71
Applied Mathematics	13	63
Applied Communication or Business Communication	13	41
Total	56	175

The survey results show that 14 schools were offering, at the time of the survey, the second-year curriculum of Principles of Technology. A total of 224 students were enrolled

in 16 classes the second year of PT. Fifteen schools were offering, at the time of the survey, the second year curriculum of Applied Mathematics. A total of 417 students were enrolled in 21 classes the second year of AM.

Number of Articulation Agreements

Each site was asked to report the number of articulation agreements in place with community colleges that specify or include applied-academics credits before and after funding. Prior to funding, five such agreements were in place. After Boeing funding, 77 agreements were in place.

Number of Graduates and Their Performance in the Workplace

According to survey information from the 44 sites, a total of 3,265 high school graduates had benefited from applied academics resulting from Boeing funding. Although most sites did not have specific data regarding applied academics graduates' workplace performance, comments from six sites suggested that applied academics graduates had positive experiences in their workplace. Some employers favored applied academics graduates over other graduates. Because of their exposure to some equipment and software, and hands-on experience in high school, applied academics students were reported to be more confident in the workplace than other students. Some applied academics students moved on to technical institutes or other types of postsecondary education institutions.

Open-Ended Comments

In addition to responding to structured questions in the survey, respondents were encouraged to provide anecdotes that give insight into how Boeing funding helped spur innovations and changes in their school programs, faculty, and students. Respondents were also asked to suggest other ways their school district could use corporate support (not necessarily money) in the future. They were also asked about the prospects for greater business, industry, and labor participation.

Comments on the Impact of Boeing Funding

The following is a summary of comments on the impact of Boeing funding from different sites surveyed.

- Without Boeing funding, many schools could not have afforded to implement applied academics simply because of the cost of equipment and associated training. Applied academics would still be a paper concept rather than a reality.

- Boeing's support gave great credibility to applied academics and boosted staff morale in helping students with contextual learning.

- Applied academics provides a successful alternative for students who thought they could not learn mathematics or physics. Even regular academics students benefited from attending applied academics classes thought hands-on experience and contextual learning. In most schools funded by Boeing, PT equipment was shared by vocational and academic departments.

- Boeing's support served as an impetus for collaboration between academic and vocational staffs for curriculum integration.

- Applied academics has become part of the effort to restructure the current school system. Some applied academics courses have been included in the Tech Prep program or served as an example of how to relate the school to the real world in classroom teaching.

- Using Boeing as an example, schools seek to have partnerships with other businesses and industries.

- Experience gained through Boeing-funded applied academics courses is being shared not only with other Washington schools not funded by Boeing, but also with schools outside the state.

Comments on Further Business, Industry, and Labor Support for Education

- All sites surveyed were very appreciative of Boeing's support and hoped Boeing would continue and expand its support for educational reform.

- Schools are collaborating with other social agencies and other projects to form education-business partnerships.

- Business and industry can support education in various forms. The following are some examples:

  - Donating new or used equipment to schools

  - Providing opportunities for students to do job shadowing, make site visits, serve apprenticeships, and participate in summer internships

  - Providing teachers with internship opportunities

  - Providing student mentorship programs and classroom guest speakers

- Participating on advisory committees

- Special attention can be given to small rural schools that do not have ready access to education-business partnerships

Summary

AM students were similar to comparison students in overall GPA and grades in mathematics. This contradicts the misconception that AM serves only "low achievers." AM students had similar educational aspirations. The majority planned to have some post-secondary education after high school. In this study, a higher percent (44 percent) of comparison students than AM students (33 percent) would like to be employed immediately after high school. Regarding student performance on AM tests, AM students gained significantly between the pre- and post-test. They also scored significantly higher than the comparison students in the post-test. AM students were more confident about their ability to learn mathematics after a year's AM course.

PT students and comparison students involved in this study appeared different in many ways. Compared with students in traditional physics classes, the PT students had lower gradepoint averages and lower grades in mathematics and science. Many more comparison-group students were university-bound (75 percent) than PT-group students (37 percent). Comparison students also took more algebra courses. Regarding test performance, the comparison students scored significantly higher overall. However, PT students who took the same amount of algebra as the comparison group scored significantly higher on the PT items and not significantly different on the physics items. When overall grades in mathematics and science and GPA's were controlled, PT students generally scored higher on PT items (in some cases significantly so) than the comparison students. As for the physics items, PT comparison students whose overall grades in mathematics and science were "C" or higher or whose overall GPA was above 1.9 scored significantly higher than PT students with the same characteristics. No significant difference was found among students of the two groups whose overall grades in mathematics and science were below "C" or whose overall GPA was below 2.0.

The results of the survey of the impact of the Boeing Applied Academics project strongly suggested Boeing funding was crucial in making the concept of applied academics a classroom reality. The funding was used for different purposes, particularly for purchasing equipment and material for applied academics. The number of students served and of schools offering applied academics courses increased dramatically during Boeing funding, a trend that remained even after funding stopped. Some schools have started to offer the second-year curriculum of PT and AM. Systematic data on the workplace performance of students who benefited from applied academics were not available. However, anecdotes

from different sites indicated that those students were doing well in their jobs and were complimented by employers for their hands-on experience and comfort with equipment. Overall, all sites surveyed were very appreciative of the support they received from Boeing and hoped that Boeing support would continue. They made some suggestions for further business, industry, and labor support for educational partnerships.

Conclusion

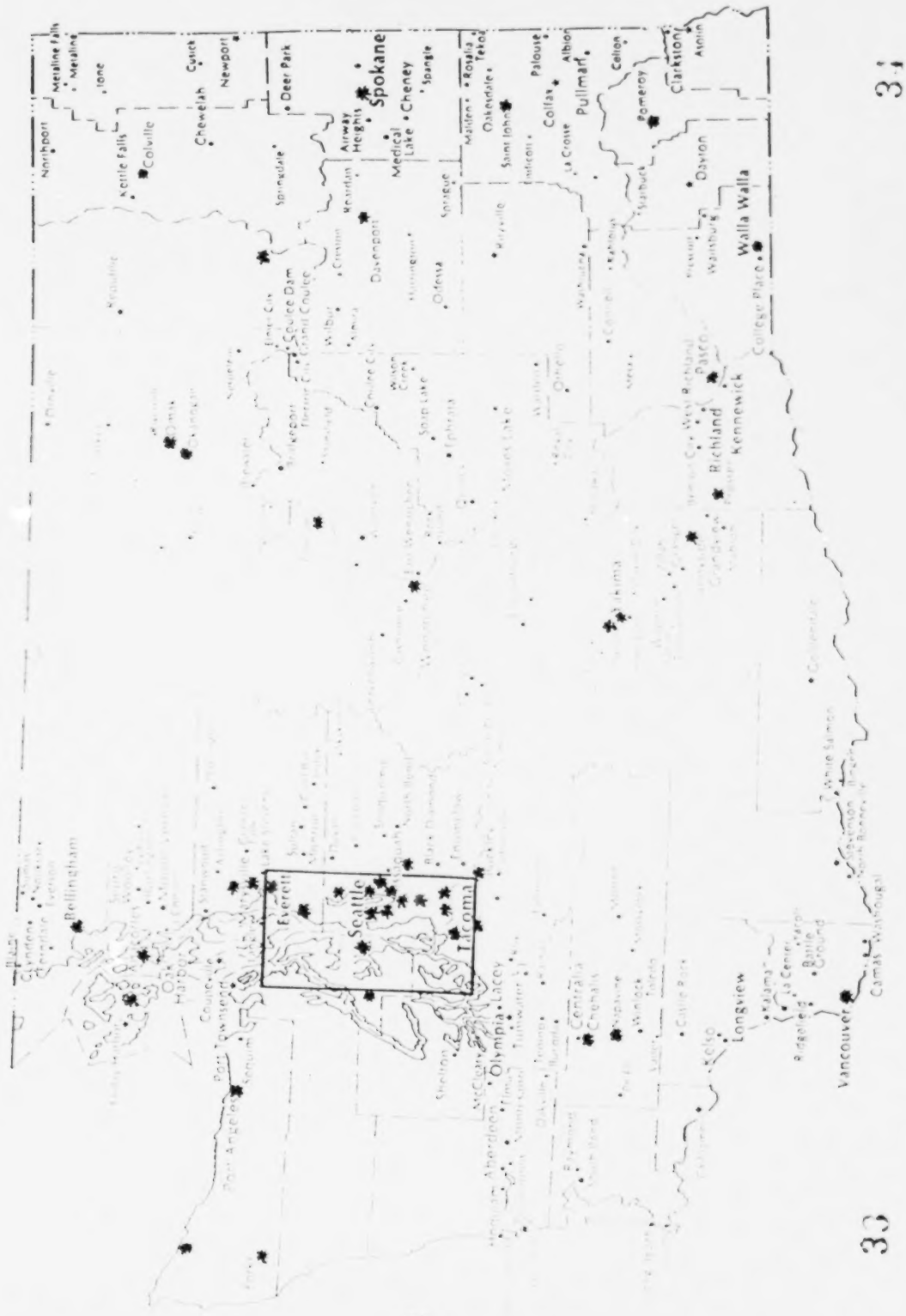
The evaluation results of this year and of the previous three years strongly suggest that Principles of Technology and Applied Mathematics provide students challenging alternatives to traditional academic classes. This new approach appears to increase students' confidence in their ability to learn mathematics and science. The results of student tests in these two areas indicate that PT and AM were not only challenging for applied academics students, but also for those enrolled in traditional mathematics or physics classes (including those who are university-bound).

In the past two years when comparison groups were used, AM students in every category constantly scored significant higher than their peers in traditional mathematics classes. Although PT comparison students appeared to score significantly higher at first glance, PT students were actually doing equally well and sometime better when certain variables were kept constant, such as overall GPA and grades in mathematics and science. Since more "low achievers" were enrolled in the PT classes than in traditional physics classes, test scores tended to skew in favor of PT comparison students when student academic backgrounds were not controlled in analysis.

The results of student surveys show that AM and PT students who were at the lower end in academic achievement tended to gain greatest in applied academics courses. They were also found to be more confident about their ability to learn mathematics and science. However, AM and PT classes should not be confined to a particular group. They should be open to any student who wants a new perspective on mathematics and physics. It is important that these classes be viewed by students and staff as an alternative way, *but not an easy way*, to learn mathematics and physics. The appropriate amount of mathematics students take could determine how much they can benefit from AM or PT classes. Certain prerequisites need to be set for PT and AM classes so students enrolled in these classes can take full advantage of an alternative way of learning mathematics and science.

APPENDIX A

Applied Academic Sites Funded by The Boeing Company (1990 through 1994))


Spokane
Seattle
Everett
Tacoma
Olympia
Bellingham
Longview
Vancouver
Walla Walla
Richland
Pullman
Moses Lake
Wenatchee
Yakima
Ellensburg
Port Angeles
Aberdeen
Centralia
Chehalis
Kennewick
Clarkston
Colville
Deer Park
Cheney
Medical Lake
Airway Heights
Davenport
Odessa
Ritzville
Colfax
Palouse
Albion
Pomeroy
Dayton
Othello
Quincy
Ephrata
Soap Lake
Grand Coulee
Bridgeport
Omak
Oroville
Tonasket
Republic
Kettle Falls
Chewelah
Newport
Metaline Falls
Metaline
Ione
Northport
Sprague
Davenport
Harbor
Shelton
Lacey
Tumwater
Kelso
Castle Rock
Battle Ground
Camas
Washougal
Stevenson
Cle Elum
Roslyn
Ellensburg
Selah
Toppenish
Sunnyside
Prosser
Benton City
Kennewick
Pasco
Richland
West Richland
Connell
Othello
Moses Lake

APPENDIX B

Applied Mathematics Student Survey

(Pre and Post-test for Applied Math Students)

Directions to Instructors: *Please tell your student to fill in the following information sheet before they start to work on the attached test. Make sure that they have 40 minutes to complete the test.*

You are: AM Students: **64%** Male **36%** Female
Comparison: **51%** **49%**

Grade Level: AM Students: **18%** 9th **49%** 10th **22%** 11th **10%** 12th
Comparison: **64%** **33%** **3%**

Are you currently enrolled in the Applied Math course? Yes No

Were you enrolled in the Applied Math course before this semester? Yes No

1. In which type of mathematics course(s) are/were you enrolled? *Circle all that apply.*

	AM	Com
General, Business, or Consumer Mathematics	**44%**	**72%**
Pre-Algebra	**50%**	**9%**
Algebra I	**35%**	**5%**
Geometry	**9%**	**0**
Algebra II	**6%**	**0**
Trigonometry	**1%**	**1%**
Pre-Calculus or Algebra III	**.3%**	**0**
Calculus	**.3%**	**0**
Technical Mathematics	**3%**	**0**
Other (*specify*) _____	**3%**	**25%**

Note: AM = Am Students, Com = Comparison Students

2. What is your **overall** grade in mathematics?

		AM	Com
Most A's	Pre	**6%**	**4%**
	Post	**7%**	**8%**
B's and some A's	Pre	**19%**	**20%**
	Post	**23%**	**15%**
B's and C's	Pre	**44%**	**46%**
	Post	**43%**	**27%**
C's and D's	Pre	**28%**	**26%**
	Post	**21%**	**36%**
D average or lower	Pre	**4%**	**3%**
	Post	**6%**	**1%**

3. Which of the following best describes your **overall** grade point average (GPA) last year?

		AM	Com
Over 3.5 (most A's)	Pre	**4%**	**3%**
	Post	**5%**	**1%**
3.0 to 3.5 (B's and some A's)	Pre	**19%**	**18%**
	Post	**17%**	**16%**
2.0 to 2.9 (B's and C's)	Pre	**50%**	**49%**
	Post	**55%**	**45%**
1.0 to 1.9 (C's and D's)	Pre	**25%**	**28%**
	Post	**20%**	**37%**
Under 1.0 (D average or lower)	Pre	**3%**	**3%**
	Post	**4%**	**1%**

4. What do you plan to do immediately after high school? *Circle all that apply.*

		AM	Com
Enroll in a community college	Pre	**40%**	**28%**
	Post	**35%**	**29%**
Enroll in a 4-year college or university	Pre	**19%**	**23%**
	Post	**18%**	**12%**
Enroll in a trade or technical school	Pre	**14%**	**12%**
	Post	**19%**	**17%**
Join the military	Pre	**12%**	**9%**
	Post	**10%**	**8%**
Get a job	Pre	**32%**	**52%**
	Post	**33%**	**44%**
Something else (*specify*)_____		**11%**	**7%**

5. In the current applied math class you are taking, how much emphasis does your teacher place on each of the following objectives? *Circle one response for each statement.*

Area of Emphasis		None		A Little		Some		A Lot	
		AM	Com	AM	Com	AM	Com	AM	Com
Increasing your interest in mathematics	Pre	15%	9%	27%	35%	36%	39%	22%	17%
	Post	16%	12%	23%	30%	41%	37%	20%	22%
Learning and memorizing facts, rules, and steps	Pre	7%	10%	24%	31%	41%	34%	29%	25%
	Post	8%	3%	27%	30%	36%	43%	29%	24%
Preparing you for further study in math	Pre	7%	7%	18%	22%	51%	39%	24%	32%
	Post	7%	6%	21%	29%	40%	37%	33%	29%
Thinking about what a problem means and the ways it might be solved	Pre	5%	6%	12%	17%	38%	31%	45%	47%
	Post	4%	4%	19%	25%	35%	30%	42%	41%
Showing you the importance of mathematics in daily life	Pre	9%	14%	19%	14%	36%	39%	37%	32%
	Post	6%	7%	19%	26%	31%	27%	45%	40%

6. How far in school did your mother (or female guardian) go? *Circle one response.*

	AM	Com
Did not finish high school	16%	27%
Graduated from high school or equivalent(GED)	29%	28%
After graduating from high school, attended vocational school, a junior college, a community college, or another type of two-year college	16%	7%
After graduating from high school, went to college but did not complete a four-year degree	10%	7%
Graduated from college	7%	3%
Master's degree or equivalent	3%	4%
Ph.D., M.D., or other advanced professional degree	2%	8%
Don't know	17%	16%

7. What is your ethnic background?

	AM	Com
Asian or Pacific Islander	2%	3%
Hispanic, regardless of race	16%	34%
Black, not of Hispanic origin	2%	1%
White, not of Hispanic origin	73%	60%
American Indian or Alaskan Native	7%	3%

8. How would you rate your ability to learn mathematics?

	Excellent		Good		Fair		Poor	
	AM	Com	AM	Com	AM	Com	AM	Com
Pre	11%	11%	45%	4%	37%	37%	7%	4%
Post	16%	5%	49%	41%	29%	43%	7%	11%

9. How many additional math courses would you like to take in high school and beyond:

	None		One		Two		Three		Four		Five or more	
	AM	Com	AM	Com	AM	Com	AM	Com	AM	Com	AM	Com
Pre	**20%**	**11%**	**22%**	**21%**	**27%**	**31%**	**19%**	**24%**	**7%**	**11%**	**4%**	**3%**
Post	**27%**	**15%**	**21%**	**23%**	**24%**	**22%**	**15%**	**19%**	**7%**	**15%**	**6%**	**6%**

10. An important skill in the workplace is the ability to make reasonable estimate of costs or quantities. List as many examples as possible (up to five) of **job titles** and **work situations** in which different workers may need to use this skill.

Job Title	**Work Situation**
Example: Contractor	Estimating the number of roof tiles needed for 2000 sq. foot house
1.	
2.	
3.	
4.	
5.	

The mean response was **3** jobs

The average pre-test score: AM Students = 15.7 Comparison = 13.0
post-test score: AM Students = 19.0 Comparison = 14.7

Please wait for your instructor to tell you to begin the test.

APPENDIX C

Principles of Technology(PT)
Student Information Sheet
(Post-test for PT Students)

Directions to Instructors: *Please tell your student to fill in the following information sheet before they start to work on the attached test. Make sure that they have 45 minutes to complete the test.*

You are: PT Students: **71%** Male **29%** Female
Comparison: **64%** **36%**

Grade Level: PT Students: **21%** 9th **27%** 10th **30%** 11th **22%** 12th
Comparison: **17%** **3%** **24%** **57%**

Are you currently enrolled in the Principles of Technology course?

PT Students: **99%** Yes **1%** No
Comparison: **6%** **94%**

Were you enrolled in the Principles of Technology course before this semester?

PT Students: **9%** Yes **91%** No
Comparison: **5%** **95%**

1. In which type of mathematics course(s) are you enrolled or have you completed in high school? *Circle all that apply.*

	PT	Com
General, Business, or Consumer Mathematics	**24%**	**23%**
Pre-Algebra	**50%**	**44%**
Algebra I	**71%**	**67%**
Geometry	**43%**	**73%**
Algebra II	**37%**	**73%**
Trigonometry	**12%**	**57%**
Pre-Calculus or Algebra III	**6%**	**47%**
Calculus	**3%**	**22%**
Technical Mathematics	**1%**	**1%**
Other (*specify*)_____	**7%**	**6%**

Note: PT = PT Students *Com = Comparison Students*

2. What is your **overall** grade in mathematics?

		PT	Com
Most A's	Pre	17%	43%
	Post	17%	42%
B's and some A's	Pre	30%	36%
	Post	25%	31%
B's and C's	Pre	36%	17%
	Post	37%	25%
C's and D's	Pre	16%	4%
	Post	17%	3%
D average or lower	Pre	1%	0
	Post	4%	0

3. What is your **overall** grade in science?

		PT	Com
Most A's	Pre	21%	45%
	Post	22%	45%
B's and some A's	Pre	31%	34%
	Post	27%	34%
B's and C's	Pre	33%	17%
	Post	34%	17%
C's and D's	Pre	13%	4%
	Post	12%	4%
D average or lower	Pre	2%	1%
	Post	5%	1%

4. Which of the following best describes your **overall** grade point average (GPA) last year?

		PT Students		Comparison	
Over 3.5 (most A's)	Pre	19%	Pre	50%
	Post	19%	Post	52%
3.0 to 3.5 (B's and some A's)	Pre	29%	Pre	35%
	Post	28%	Post	34%
2.0 to 2.9 (B's and C's)	Pre	39%	Pre	11%
	Post	41%	Post	11%
1.0 to 1.9 (C's and D's)	Pre	11%	Pre	3%
	Post	11%	Post	3%
Under 1.0 (D average or lower)	Pre	1%	Pre	1%
	Post	2%	Post	1%

5. What do you plan to do immediately after high school? *Circle all that apply.*

		PT	Com
Enroll in a community college	Pre	29%	17%
	Post	35%	21%
Enroll in a 4-year college or university	Pre	44%	81%
	Post	37%	75%
Enroll in a trade or technical school	Pre	18%	4%
	Post	16%	4%
Join the military	Pre	8%	5%
	Post	8%	4%
Get a job	Pre	27%	19%
	Post	26%	19%
Something else (*specify*)_____		10%	6%

6. In the current Principles of Technology class you are taking, how much emphasis does your teacher place on each of the following objectives? *Circle one response for each statement.*

Area of Emphasis		None		A Little		Some	
		PT	Com	PT	Com	PT	Com
Increasing your interest in science	Pre	9%	8%	25%	21%	42%	40%
	Post	8%	9%	21%	21%	45%	44%
Learning and memorizing science facts, rules, and steps	Pre	7%	4%	27%	31%	41%	45%
	Post	8%	9%	27%	32%	36%	42%
Preparing you for further study in science	Pre	9%	3%	24%	22%	40%	48%
	Post	12%	6%	21%	22%	42%	44%
Thinking about what a problem means and the ways it might be solved	Pre	4%	2%	11%	12%	31%	34%
	Post	6%	5%	25%	15%	38%	37%
Showing you the importance of science in daily life	Pre	5%	4%	17%	22%	32%	44%
	Post	5%	8%	13%	23%	31%	37%

7. How far in school did your mother (or female guardian) go? *Circle one response.*

	PT	Com
Did not finish high school	7%	3%
Graduated from high school or equivalent(GED)	26%	21%
After graduating from high school, attended vocational school, a junior college, a community college, or another type of two-year college	18%	18%
After graduating from high school, went to college but did not complete a four-year degree	14%	16%
Graduated from college	13%	25%
Master's degree or equivalent	8%	10%
Ph.D., M.D., or other advanced professional degree	2%	1%
Don't know	13%	6%

8. What is your ethnic background?

	PT	Com
Asian or Pacific Islander	**5%**	**10%**
Hispanic, regardless of race	**8%**	**2%**
Black, not of Hispanic origin	**2%**	**1%**
White, not of Hispanic origin	**80%**	**86%**
American Indian or Alaskan Native	**5%**	**1%**

9. How would you rate your ability to learn mathematics?

	Excellent		Good		Fair		Poor	
	PT	Com	PT	Com	PT	Com	PT	Com
Pre	**22%**	**44%**	**52%**	**46%**	**22%**	**9%**	**4%**	**1%**
Post	**24%**	**43%**	**46%**	**43%**	**26%**	**12%**	**5%**	**2%**

10. How would you rate your ability to learn science?

	Excellent		Good		Fair		Poor	
	PT	Com	PT	Com	PT	Com	PT	Com
Pre	**21%**	**36%**	**50%**	**49%**	**24%**	**13%**	**5%**	**2%**
Post	**20%**	**35%**	**48%**	**50%**	**26%**	**14%**	**6%**	**2%**

11. How many additional science/technology courses would you like to take in high school and beyond

	None		One		Two		Three		Four		Five or more	
	PT	Com	PT	Com	PT	Com	PT	Com	PT	Com	PT	Com
Pre	**17%**	**9%**	**18%**	**12%**	**32%**	**24%**	**15%**	**19%**	**5%**	**7%**	**13%**	**30%**
Post	**20%**	**10%**	**18%**	**12%**	**27%**	**23%**	**17%**	**13%**	**5%**	**12%**	**13%**	**30%**

12. Many jobs involve an understanding of physics. List as many examples as possible (up to five) of **job titles** and **work situations** in which different workers may need to use physics.

Job Title	**Work Situation**
Example: Design Engineer	Designing new exercise equipment
1.	
2.	
3.	
4.	
5.	

The mean response was **3** jobs.

The average pre-test score: PT Students = **15.2** Comparison = **18.2**
post-test score: PT Students = **18.1** Comparison = **20.0**

Please wait for your instructor to tell you to begin the test.

APPENDIX D

Survey of the Impact of the Boeing Applied Academics Project

1. What is the total number of schools in your school district that have received Boeing funding for applied academics? Total Number **53**

   Please give the name of the school(s) and mark those schools who also received services relating to applied academics from community colleges or consortia funded by Boeing for applied academics. **Six schools were checked**

2. In which school year did your school district start to receive Boeing funding for your applied academics. *Please check.*

   28 = 1990-91 **20** = 1991-92 **12** = 1992-93 **8** = 1993-94

3. What is the amount of funding your school district received from The Boeing Company for each school year? What is the amount of funding (excluding Boeing funding) your school district spent on applied academics (excluding teacher salaries) for each school year? *Please fill in the following chart.*

School Year	Boeing Funding ($)	Non-Boeing Funding ($)	Total ($)
1990-91			
1991-92			
1992-93			
1993-94			
Total ($)			

4. The Boeing funds were used for the following purposes. *Please check all that apply.*

   96% To purchase equipment for applied academics
   39% To develop or modify curriculum for applied academics
   77% To purchase applied academics materials
   52% Staff training
   14% Articulation planning
   5% Other (specify) _____

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Please give specific information of how Boeing funds were used in supporting your applied academics efforts. Please try to separate Boeing funds from Perkins funds, but if that is impossible, point out the leveraging power Boeing funds may have offered? (e.g., we trained *this many* high school math teachers, we held *this many* workshops for counselors, we developed coordinated curriculum paths for *this many* subject areas. **Please feel free to attach additional documents to respond to this and other open-ended questions in this survey.**

We have trained a total of three individuals in Applied Math, two in Principals of Technology and one in Applied Communications.

We trained 3 PT teachers. We purchased lab equipment. We purchased consummables. We purchased instructional equipment. We funded Applied Communication, Applied Vocational Math, Applied BioChemistry ourselves!

Through Boeing funds, we were able to have a computer lab for Applied Communications and Applied Math. This would not have been possible without the grant. Seventeen work stations were established. One has been added with Perkins moneys. The CORD materials/software licenses were also obtained, along with staff inservice. This investment has made it possible for students in a rural area to have state-of-the-art education in these two areas. It is not financially possible to have Principles of Technology. There is a real need in this area with the changing demands of the job market.

We would not have started PT without Boeing funds. We now have 4 sections and will be training an additional teacher. PT II cannot be started because we do not have the menus.

Two teachers were trained; the principal of tech program was the first real impetus to the project--the main obstacle was our own vocational state dept which held unrealistic rules requiring that only vocational staff could teach it for vocational funding. This restricted our flexibility.

Grant provided funding to train/inservice staff in Applied Academics prior to introduction into the classes. Funds were also used to purchase 7 modules which were shared by 14 teachers.

This process then led to implementation for a Career Integrated Academics program during 1991-2 so that our students could earn academic credit as well as vocational credit.

Purchase Principles of Technology lab equipment.

Purchase Principles of Technology equipment.

Mini Grants for Tech Prep: 6 workshops for teachers, health occupations $5,000, 4 workshops for teachers, human and health services career paths $3,000.

Vocational Funds (not Carl Perkins): Material science technology and Principles of Technology training $5,000.

We have trained 26 teachers in applied academics. Seven have been supported by Boeing funds.

Boeing funds provided team teaching of an academic and vocational teacher to team teach the class of Applied Mathematics in its first year. The funds paid for 2 (1 class period) for 180 days to accomplish this. Also some of the materials necessary to pilot the class were provided through Boeing funds.

Boeing funds were used as "seed" money to cover start-up costs of PT. The funds then created a need to reprioritize other funds to provide continued support of the PT class.

Trained (1) Applied Math instructor; purchased (15) sets of student texts; purchased approximately $400 classroom support equipment; and purchased new TW, VCR, and CORD tapes.

Boeing funds purchased equipment and materials to start up the Applied Academics program: 12 students enrolled the first year, 24 the second, 40 the third year. We trained one certified instuctor in Principles of Technology.

Boeing funds were directly attributed to purschasing Lab Volt equipment for Principles of Technology (applied physics). Local effort by Walla Walla School District have been attributed to support for supplies and materials, instructional materials, contractual service, inservice travel and capital outlay since the Boeing Grant was provided in 1990-91.

We provided teacher inservice and purchased supplies and equipment that enabled us to add PT to our curriculum. This offering would not have been available otherwise.

Okanogan School District arranged for one technical education instructor to be trained in Principles of Technology. Equipment was purchased for a science lab in the vocational department. Without Boeing funds, none of this would have happened.

Boeing funds were the incentive for providing a PT lab in our high school. This lab created an interest by other staff members and as a result more applied courses have emerged and integration of courses/staff has been possible.

Boeing funds were needed for equipment purchase only--Principles of Technology.

Boeing funds were used for start-up costs of Principles of Technology. Equipment and materials were purchased.

The Boeing money launched us into developing and integrating science and Technology program.

Boeing funds were used to purchase 7 lab experiment/lab storage benches from ECI Co., plus purchase 1 lab station equipment package for students. Purchased from Netts Co., North Bend, WA.

To purchase PT equipment.

The funds were responsible for us starting our applied math sections. Before we received the funds we had no Applied Math; now we have 3 intro sections and are working on an advanced.

We trained one teacher for Principles of Technology--attended workshop in the summer so he was qualified to teach PT.

Funds used: purchase of Principles of Technology Lab with computers and support materials $30,000; $12,000 inservice stuff in Applied Communications and purchased the modules from CORD/ATT.

The grant money was used to purchase equipment and materials to start up Principles of Technology.

Trained 2 math teachers, 1 communications teacher.

Purchased 2nd year equipment for Principles of Technology.

Trained one science teacher and one Industrial Arts teacher in the area of Principles of Technology.

All of the Boeing funds were used to purchase additional Principles of Technology equipment and to train the teacher to teach the program.

The first year (1990-91) the Boeing dollars went to Applied Math and Applied Communication. Because of the planning our District/Voc Ed funded 5 schools.

The Boeing funds were used for equipment purchases. The other costs were paid by the Seattle Public Schools.

1. We supplied PT equipment for lab. The school supplied a room with tables, storage, gas, water, and compressed air supplies.

2. We trained 2 instructors at PT workshop (1 vocational and 1 basic education). Team teaching and crosscrediting have occurred in this PT course.

3. Monies leveraging training for 4 teachers (1 vocational and 3 math) for Applied Math classes. The Applied Math was used 1 year (1990-91) and then dropped until 1994-95 when we will have 1 Applied Math class.

4. Crosscrediting and college entrance acceptance is a great help to the students in PT classes.

5. Boeing's influence has helped teachers re-think and evaluate curriculum for workforce and future job market.

Funds sent teacher to 6 inservice and training. Funds purchased books and equipment needed to start class.

Boeing funds were used to purchase some Principles of Technology equipment.

We have had 1 $5,000 grant to set up Applied Math a Collins High School. We have had 3 Applied Math teachers go through the Boeing summer internship program.

Start up a new PT program; service 105 students; train one instructor.

We used the $30,000 to purchase PT stations at the 2 high schools. The remaining costs were covered by district vocational funds.

The funds were spent on CORD books and materials. The Principles of Technology class was started. Equipment for this class was bought. The teacher was sent to the 2 week PT training.

We trained 3 English and 3 Business Education teachers in Applied Communication. We purchased curriculum materials and equipment to implement program.

We trained one high school math teacher. We purchased materials to cover Applied Math.

The funds were used to purchase the Principles of Technology (Applied Physics) materials. We were able to put district funds into Applied Math.

We trained 1 teacher for 2 weeks on Applied Physics curriculum. We purchased $30,000 worth of equipment for Principles of Technology. Part of that $30,000 purchased the curriculum.

5. What is your best estimate of total number of students in your school district enrolled in applied academics courses the year before receiving Boeing funding? What is the enrollment during Boeing funding? What is the enrollment after Boeing funding?

Course	Student Enrollment		
	Before	During	After
Principles of Technology	**836**	**1910**	**2446**
Applied Mathematics	**309**	**1127**	**1519**
Applied Communication/Business Communication	**107**	**1367**	**1540**

6. How many schools in your school district offer applied academics courses before Boeing funding? How many now? *Please fill in the following chart.*

Course	Number of Schools	
	Before	Now
Principles of Technology	**21**	**62**
Applied Mathematics	**13**	**54**
Applied Communication	**13**	**23**

7. How many schools in your district offer the second year curriculum of Principles of Technology or Applied Mathematics?

a. Principles of Technology	b. Applied Mathematics
14 Number of Schools	**15** Number of Schools
16 Number of Classes	**21** Number of Classes
224 Number of Students	**417** Number of Students

8. In your school district, how many articulation agreements were in place with community colleges that specify or include applied academics credits before Boeing funding? How many now? *Please fill in the following chart.*

	Before Boeing Funding	Now
Number of Articulation Agreements	5	77

9. Have you graduated some students who have benefited from the applied academics resulting from Boeing funding?

96% Yes **4%** No

If yes, how many? **3,265** High School Students

10. Do you know anything about their workplace performance so far?

21 %Yes **79%** No

If yes, please describe.

11. Please provide any vignettes you can offer that might give real insights into how the Boeing grant has helped spur innovations/changes in your school system or in people: How influential is this kind of attention from the private sector? Has it prompted other business/industry/labor support and participation? How is your school district building on the momentum? Were teachers' eyes really opened to new possibilities? Have you had some individual graduate success stories you can now share?

We have a fairly large number of students who think they are incapable of reading a technical manual or using higher level thinking skills. One in particular is in special education and struggled in beginning Principles of Technology. Now he sets up second year labs almost by himself and does so because he is a hands-on learner. Having the grant money has allowed our school to reach and teach applied physics to those that *thought* they couldn't learn.

Principles of Technology would not have been started without the Boeing Grant. It has been very beneficial to students in our school district, especially those continuing into tech prep programs at Walla Walla Community College.

The Science Department finally realized the importance of application and hands-on.

Our teachers have bought in and are the reason the numbers are increasing.

Receiving a Boeing grant provides the initial starting point for one school to see the real value of the computer in the classroom--its transfer to the work world for our students. Educators and students do feel "big business" does care and has concern of what is to be the educational processes for today and tomorrow. Our district is proud of its applied academics and there increased offerings in applied science classes (agriculture). Other educational institutions have viewed /filmed our facilities. Many times we have been contacted as a resource. Thanks Boeing for giving us this start!

Enabled us to offer a course that would not otherwise be offered.

PT has been team taught by a voc. and basic ed. teacher for 1 year. Great success!
PT was integrated with English, in a 2 hour block, for 1 trimester. The English portion was Technical reading and writing. The program was call "Connections." More information if you need it.

Applied Mathematics will be offered in 1994-5 school year for students in high school.
Voc. ed. emergency certification (1 year) for teachers in basic ed. to teach and learn about voc. ed. programs.

More movement to word integration of subject matter areas and emphasis on workforce readiness.

The Boeing project provided the financial support to begin the applied academics curriculum. Attached is a chart showing the applied academics classes now in place in Yakima school district. The Boeing project was an excellent beginning role model. We have been able to greatly expand applied academics opportunities to students utilizing that role model.

The Boeing grant gave notice to the faculty of the high school that we were very serious about applied academics. Although the applied math was a disaster the first year, we still have established a strong foothold for applied academics in the future.

This particularly helped to break barriers between academic and voc teachers. Helped to show relevance and application of basic academic concepts.

Credibility was a large factor in the way in which the grant promoted applied academics. That Boeing would sponsor teachers' training and involvement in the class brought important attention of the school, students and community. The academic departments now more readily accept applied academics.

We involved both vocational and academic teachers in the training. The effect was to bring changes to the way the teachers approach instruction in their "regular" classes as well as the applied academic classes.

Science Dept in our school covetous for our equipment. Physics classes borrow some equipment.

PT program growing lots. More students enrolled than ever.

Some students report PT background advantageous in voc. schools. Regular physics and PT students are enhanced by PT class.

Any gains in academic/vocational integration have been negated by declining enrollment (students) which constantly puts one group of staff against another.

Boeing $ was critical for us to equip 3 PT labs. The teachers of these classes and our applied math classes have helped read their schools in applied learning and have been on teams to develop project-based learning in academic classes.

The Boeing summer internships have created additional interest and excitement among teachers and students. We don't have any individual stories to share.

If it wasn't for this extra money our district could not have initiated the class.

Increased participation from students is the key. Students benefit and that's what it's all about. Partnerships with industry is becoming a must, to provide our children with opportunities equal to those of other nations.

Too early.

Current move to more applied academic classes in math and English. Dollars provided by Boeing helped get PT program started much sooner due to equipment costs being hard to afford.

Our school district could not have trained teachers or purchased curriculum/lab materials without Boeing grant of $30,000 (that's one half of our entire yearly building budget for 33 FTE teachers)

Developing a combined science/technology curr using the PT curr has greatly improved both programs.

Boeing grant provided the mechanism (money) to start a new program. Without the funding the district would not have been able to do so, simply because of the equipment, associated personnel training costs.

As addressed in #4, the grant provided funding to implement the Applied Academics into the regular classes. This led to incorporation into a Career Integrated Academics program where students were able to receive credit on campus for language arts and social studies credits.

The program has also been incorporated into the curriculum of individual Skills Center programs to support personal and professional curriculum as outlined in #10 above.

"This is the first science class that I have ever understood" - senior's comment.
A number of students have pursued technical careers as a result.

Other science/occ ed teachers were envious when they saw new equipment purchased with Boeing $. My students realize what they work with is the best!

We have begun curriculum integration K-12. We have implemented Career Paths beginning at the 8th grade. We have increased coordinators by 3.5 FTE's for work-based learning. We have one career academy and more being developed. We have secured internships for five students in the Health Occupations program at Madigen Army Hospital.

We really could not have begun this important class had it not been for the grant $. Many of our students would either not take physics or struggle with it, this course (PT) gives them an opportunity to have success in another science class.

Integrating the curriculum between PT and the academics.

Offered an opportunity to "clean-up" some of our facilities.

PT was team taught with a science teacher--so the science department recognized the value of the industry-based science approach. This is also true of the math department. The private sector contribution served as an impetus for collaboration between the math/science and Vocational Department, however, no other private sector has attributed to Applied Academics. We are looking at integrating other academic and vocational classes.

We are in the process of restructuring and many teachers see the value of applied academics. As a result of the grant the facilities have been shared with other departments and true integration of staff and content has occurred. Innovative projects have also been initiated by the instructor of PT.

The grant provided a solid base to start applied academic courses throughout the district. Students and staff witnessed the dynamics of applied and integrated instruction.

For us applied academics has provided the needed link for real articulation from the sending schools in our district to the community college. It provides credibility that what students do in our classrooms/programs will lead to workplace readiness and success.

The Boeing grant made the PT programs a fact rather than just a paper concept. Without the funds the program would not have happened. The first program paved the way for applied math and business communications.

Overall, attention has been positive and has influenced participation/cooperation with local firms.

The summer of 1994 the Tacoma School District entered into an agreement with the Chamber of Commerce to allow teachers to do an internship. Six teachers participated. This year 1994-5 we would like these businesses to allow student to job-shadow or provide part-time jobs.

12. What are some other ways your school district could use corporate support (not necessarily money) in the future? What are the prospects for greater business/industry/labor participation in the future?

It would help if we had access to more equipment, like strobe lights, multimeter (digital and analog), lasers and similar equipment.

It would be even more helpful if we could get speakers from industry to walk through a lab exercise with a class and then explain how that lab relates to their job or industry.

Walla Walla School District appreciated the Boeing Grant to begin Applied Physics or Principles of Technology. Continued support from corporate sponsors, including the Boeing Company, would be appreciated to provide technology, inservice training, capital improvements in vocational education programs, and internships for staff members to improve their teaching techniques.

Guest speakers/demonstrations (technical).
Prospects are wide open for business/labor to lend their expertise, resources.

We are participating with the shadow program out of the Tri Cities to bring business in.

Partnership could be created with small rural schools. Larger schools have staff to write grants--have greater number of students who will be affected--but rural schools have excellent work ethics among its students--they have students who want to succeed. Speakers, plant tours, sharing of management concepts, procedures that could relate to a classroom, etc. could be of real benefit to education. Dialogue with classroom teachers would be a boost.

Our teachers can benefit from continual inservice offerings at Boeing. We appreciate the opportunity to work with your company.

More partnership with business/corporations in helping high schools prepare students for the future workforce (committees, etc.).

More opportunities for students to shadow and evaluate different professions and jobs.

More opportunities for teachers to talk with corporate personnel as well as workers to see "real world" of our economy. Teachers need to work in different areas of companies to learn about business/corporation survivability.

Staff training in current technology through summer internships.

Participation in Technical Advisory counsels.

Guest lectures and teachers.

Opportunities for summer employment or after graduation employment for students, who have completed applied classes or programs would be a great motivation for students.

Leadership, by companies such as Boeing, urging greater participation by business in educational internships for teachers and students would provide valuable support.

We are working at getting mentors for students and industry into the classroom to provide applications from the real world.

Could use volunteers for our advisory committee. Also work based learning sites are needed.

The Boeing summer teacher/student internships are examples of corporate support that extend beyond the classroom. Workplace based learning opportunities, including their promotion and expansion, may come from greater corporate involvement.

Teachers back to industry.

More student mentorships and employment at meaningful jobs.

Tech Prep drafting program could use support.

Continued/increased emphasis on alternatives to baccalaureate degrees as the means to provide skills/qualifications to earn a living.

Mentorships, apprenticeships and internships with business are critical for us to move forward in school to work transition.

Speakers from different jobs come into the class to related their experiences.

Career panels, job shadowing, monitory support, guest speakers, as members on advisory boards, curriculum review teams.

Industry speakers, field trips to work sites, support in teacher inservice (people support, not $)

Visits from trade/tech workers to show how they use this stuff on the job! Kids need to relate these curricula to the "real world!"

We are developing new curriculum materials.

Working in a student mentor program.

Ways district could use corporate support in the future:

1. Jobs for students
2. Jobs for entry-level completers of Skills Center programs
3. Support for the update of technology

Prospects for business/industry/labor participation in the future:

The participation in business at the Skills Center is on the increase. Our advisory committee members have grown by over 33 percent and our partnerships with business

have doubled. For continued success for partnerships between business and education to work, we need to continue working together and increasing the number of partnerships that benefit both students and business.

The White River School District is somewhat rural with few local businesses. It is difficult for students to job shadow etc. to allow students to see what the real world is like. If Boeing had a program that would allow us to send our students to see what real jobs are like, both our schools and the students in those schools would benefit. If something can be worked out, let me know.

Job shadowing, class speakers, more mentorships, internships.

Forming partnerships with local schools.

Advising school districts about trends in occupations and professions.

Coming into classrooms to relate importance of education and how it pertains to all ages.

Get more kids into job shadowing and take them to their businesses.

Most Boeing programs now seem to be Puget Sound based. Those of us not directly in the Seattle area are somewhat left out.

Service learning partnerships

Collaboration of family agencies for student support

Agencies for disadvantaged to step forward with partnerships

Transportation needs

A summer program for students to work as an intern.

Summer programs for teachers to work as interns.

More of what Boeing is presently doing and include other business, such as: student field trips, student shadowing, student internships, student mentorships, instructor internships, equipment assistance new and used.

The manufacturing technology program where industry developed the standards and competencies (along with educators) and then have instruction develop modules is excellent approach.

Field trips and tours of industrial sites.

Internships for instructors.

Job shadowing and apprenticeship programs.

Equipment that is being discarded could be used in labs.

Participation on advisory boards, tours of facilities, mentors, internships.

As part of the Shagit/Island Tech/prep consortium, labor/industry have been very active.

Support is needed for career pathway participation.

I recently was introduced to the NIDA curriculum at Boeing for electronics. I would love to be able to use these materials in our electronics program at the skills center. I hope these opportunities will be encouraged by Boeing personnel. Other support: internships for students, and teacher--not just during the summer but throughout the school year.

Equipment securement is our biggest program. We simply do not have the funds to stay current.

Support in areas of training stations, advice, and funding for equipment and innovative programs is most useful. Prospects look quite good, in my opinion.

Future partnerships hold great possibilities. Future job shadowing, ed career awareness activities would be of real importance. Additionally direct support or expertise has come from Boeing and other local businesses.

Provide part-time jobs for students, job-shadowing experiences. We need teachers and businesses to get together to be able to plan the school to work transition.

Thanks for making time to complete this survey.